Jupiter's non-thermal radio emission: Unveiling the Jovian inner radiation belts through observation and modeling

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Jupiter's "Van Allen" radiation belts have been the focus of numerous scientific investigations since their discovery in the late 1950s. Initially detected using ground based radio telescopes that observed the synchrotron emission from the trapped energetic electrons, the radiation belts were later measured directly with NASA spacecraft (Pioneer, Voyager, Galileo Probe). Continued ground based observations combined with improved models of the Jovian magnetic field and theoretical modeling have greatly improved our understanding of the radiation belts. Nevertheless, a number of poorly understood characteristics and outstanding problems connected with radiation belts remain.

Radio maps of the total intensity of synchrotron emission show two primary locations for the radiation, at the magnetic equator near 1.4 RJ, and at high latitudes near 1.4 RJ from the cloud tops. These two locations are located in very different regions in magnetic coordinates. Both regions are asymmetric and appear to change as the planet rotates. The magnetic equator centered lobes and the high-latitude emission regions have been attributed to two populations of energetic electrons. The equatorial centered emissions are produced by electrons having mirror points near the magnetic equator. The high latitude regions have been attributed to a population of electrons having small equatorial pitch angles and located between 2 and 3 Jovian radii. The origin and energy distribution of the electrons is not well understood.

Recently, the Cassini mission provided an opportunity to obtain measurements of Jupiter's non-thermal radio emission at 13.8 GHz. Measurements were successfully carried out shortly after Jupiter closest approach using the radiometer subsystem of the Cassini Radar Instrument. The resulting data provide unique information on the highest energy electrons in Jupiter's magnetosphere. Earth-based radio telescopes have difficulty measuring the synchrotron radiation at wavelengths this short because of the difficulty in separating atmospheric thermal emission from the synchrotron radiation. The 2.2 cm Cassini radiometer was used to produce 20 maps covering two complete rotations of Jupiter in both horizontal and vertical linear polarization. Cassini unambiguously detected synchrotron emission at a level of 0.44 Jy +/- 0.15 Jy (total integrated flux density adjusted to 4.04 AU). The non-thermal synchrotron emission was clearly identified distinct from the thermal emission as evidenced by its polarization and spatial distribution. The synchrotron emission was observed to be approximately 1% of the measured thermal emission from Jupiter's disk. The level of synchrotron emission measured was less than estimated from simulations using the energy spectrum and the spatial distribution from current models.

A simultaneous ground based campaign involving the VLA (operating at 20 and 90 cm) and the NASA Deep Space Network antennas (operating at 2.3, 8.5, 13.8 and 32 GHz) provided important context for the Cassini measurements. The combined data set provided a complete picture of the electron energy spectrum and distribution in the Jovian inner radiation belts. Preliminary results from the observations and modeling efforts related to these observations will be presented.

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